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(54) **INTEGRATED ANTENNA ASSEMBLY**

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(73) Assignee: **Intel Corporation**

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(22) Filed: **Dec. 22, 2010**

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(51) **Int. Cl.**

H01Q 1/24 (2006.01)
H01Q 1/22 (2006.01)
H01Q 9/04 (2006.01)

(52) **U.S. Cl.**

CPC ***H01Q 1/2275*** (2013.01); ***H01Q 9/0421*** (2013.01)

(58) **Field of Classification Search**

USPC 343/702
See application file for complete search history.

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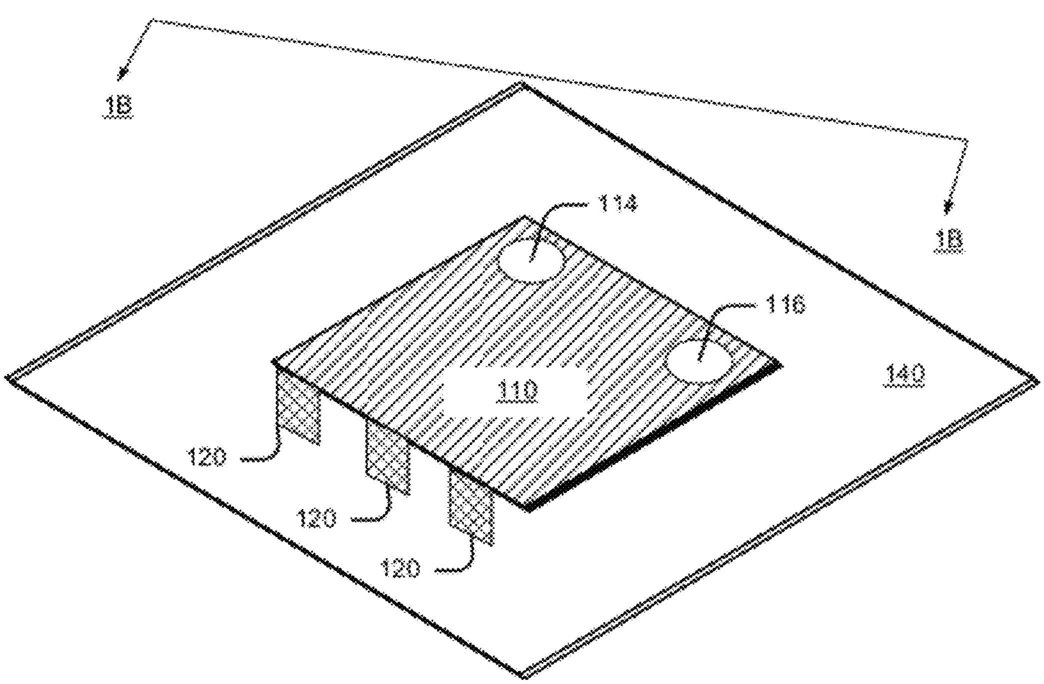
(57) **ABSTRACT**

An antenna assembly comprises a computer expansion card comprising a metallic layer which forms a radiating element or a metallic shield which forms the radiating element and a feed line coupled to the radiating element. Other embodiments may be described.

16 Claims, 8 Drawing Sheets



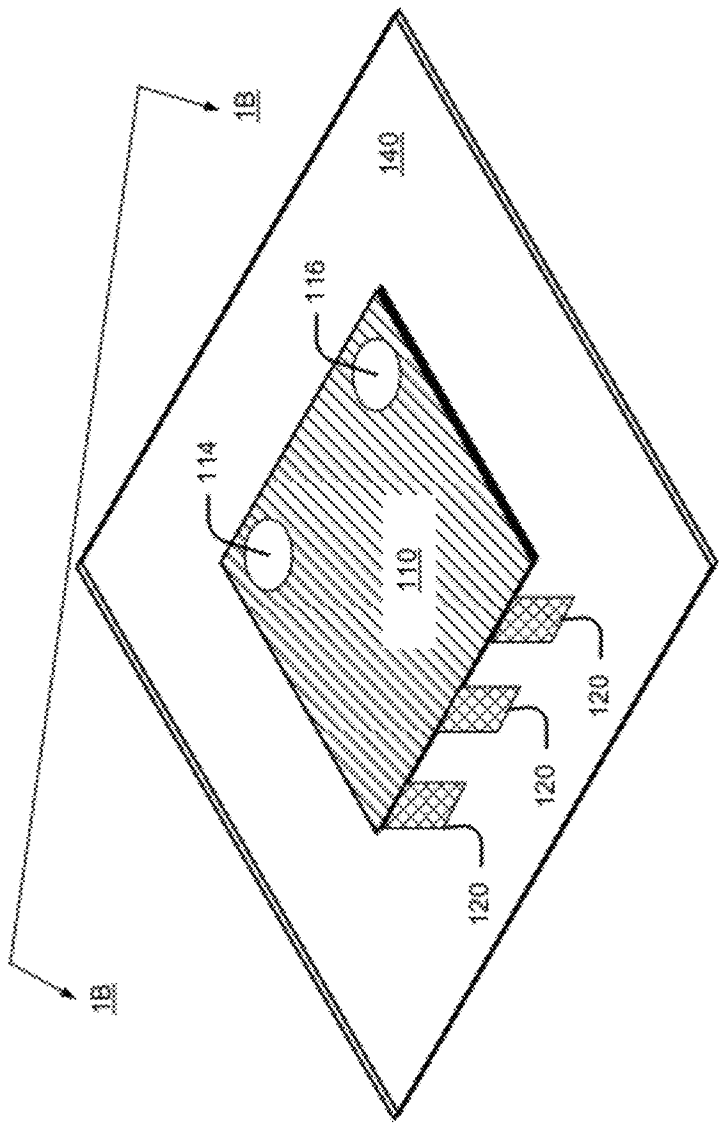


FIG. 1A

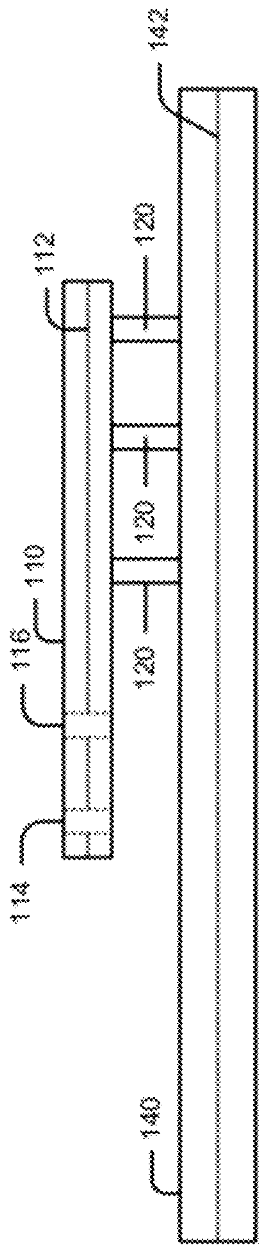

142
112
120
120
110
116
120
114
140

FIG. 1B

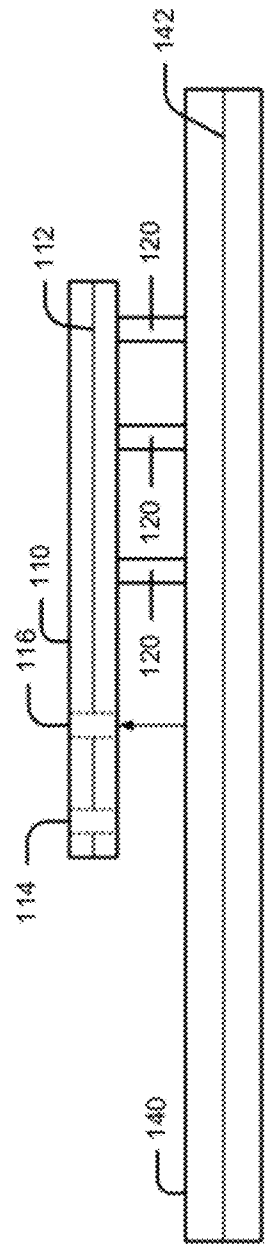

142
112
120
120
110
116
120
114
140

FIG. 1C

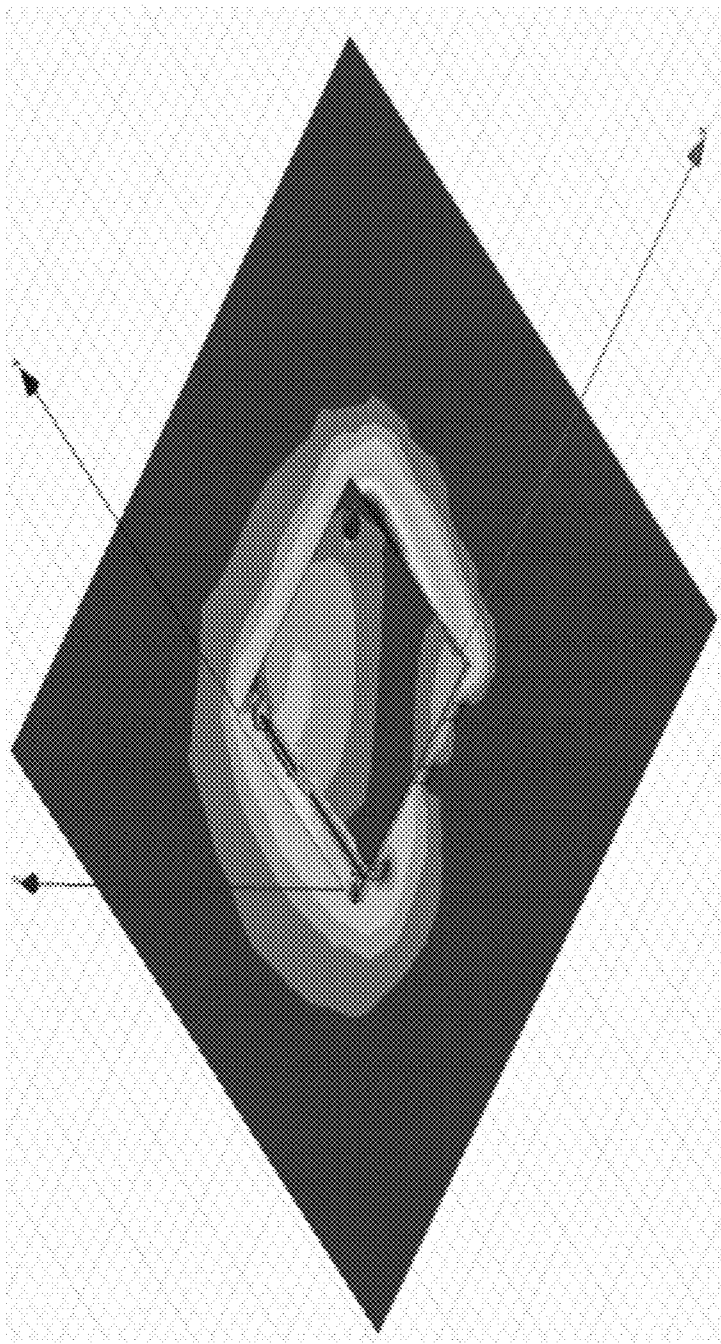


FIG. 2

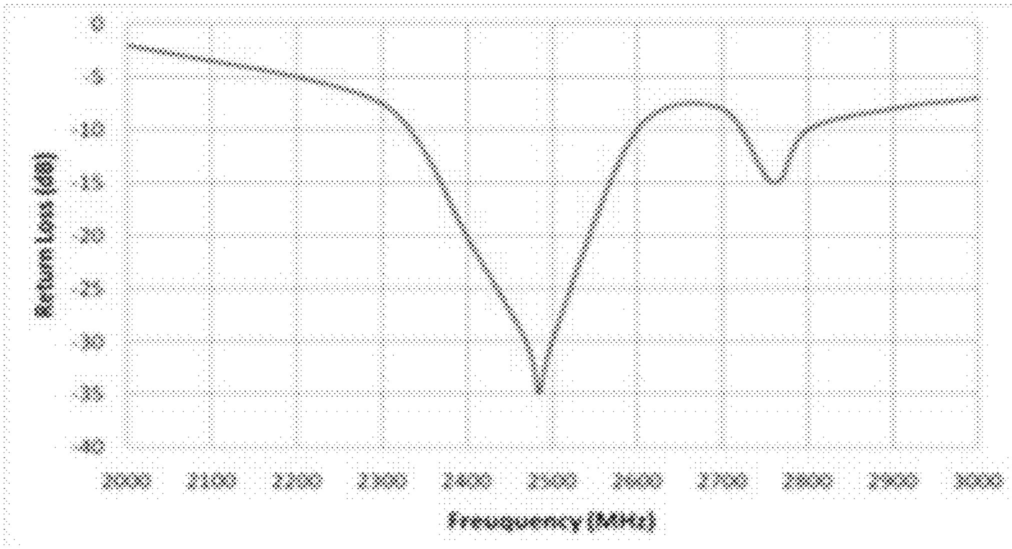

0
-5
-10
-15
-20
-25
-30
-35
-40
2000
2100
2200
2300
2400
2500
2600
2700
2800
2900
3000
Freuquency (MHz)

FIG. 3

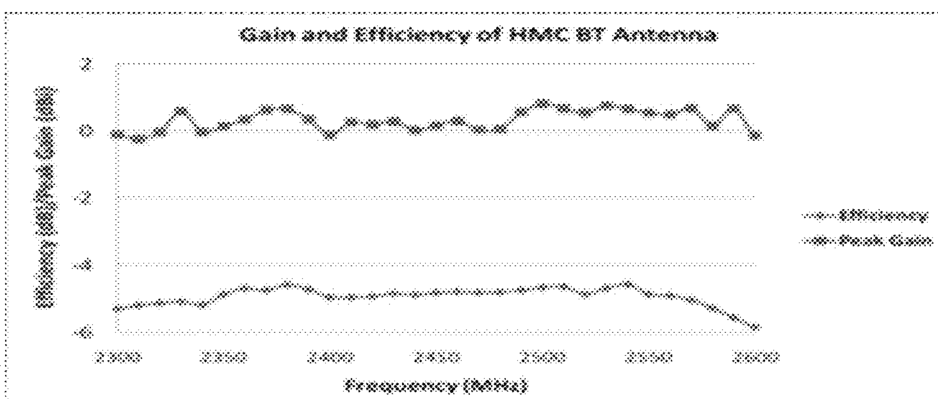

Gain and Efficiency of HMC BT Antenna
2
0
-2
-4
-6
2300
2350
2400
2450
2500
2550
2600
Frequency (MHz)
Efficiency
Peak Gain

FIG. 4

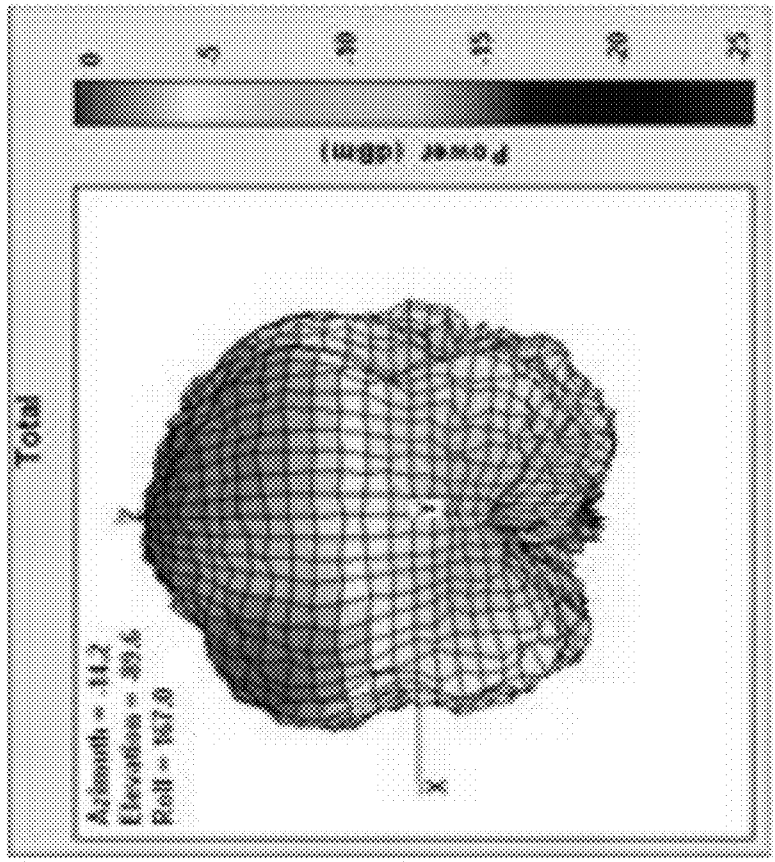


FIG. 5B

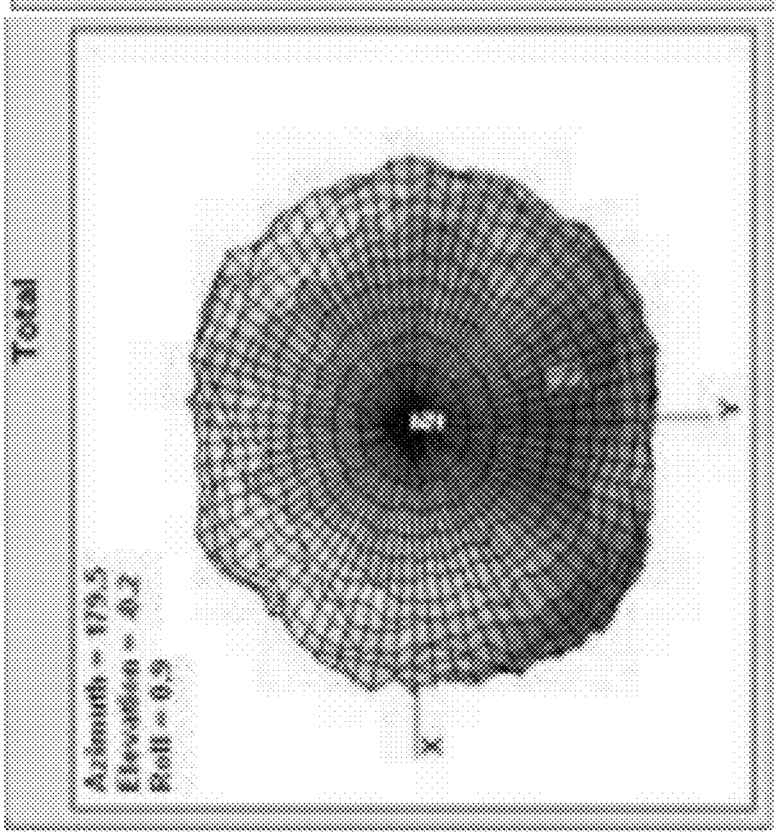


FIG. 5A

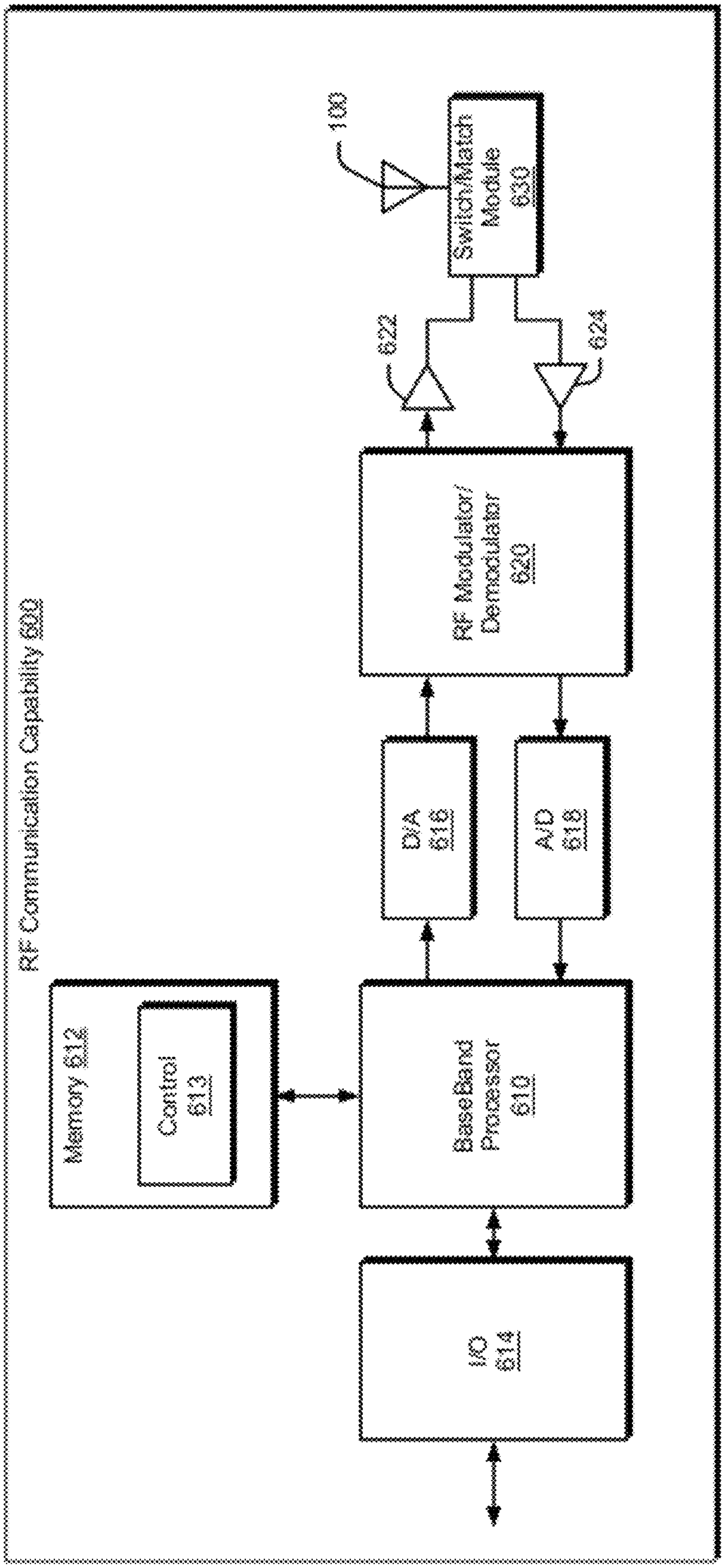

RF Communication Capability 600
Memory 612
Control 613
BaseBand Processor 610
I/O 614
D/A 616
A/D 618
RF Modulator/ Demodulator 620
622
624
Switch/Match Module 630
100

FIG. 6

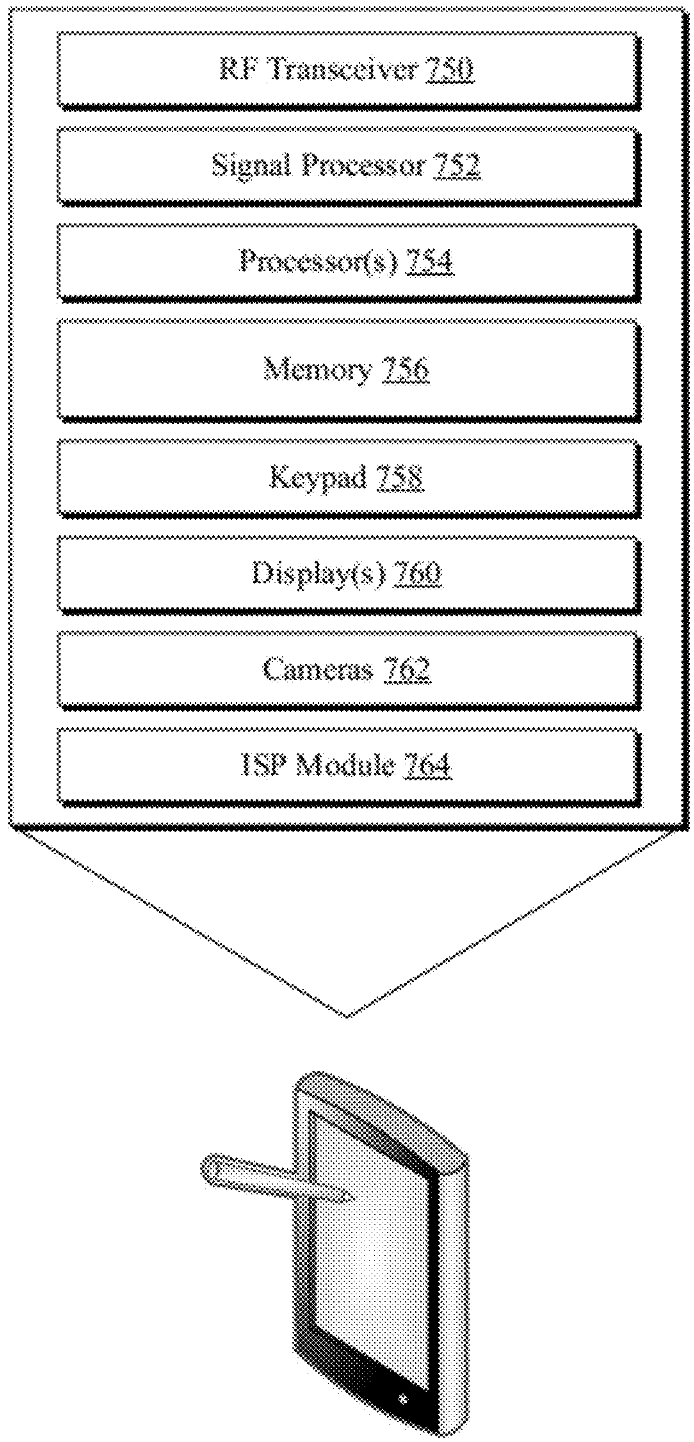

RF Transceiver 750
Signal Processor 752
Processor(s) 754
Memory 756
Keypad 758
Display(s) 760
Cameras 762
ISP Module 764

FIG. 7

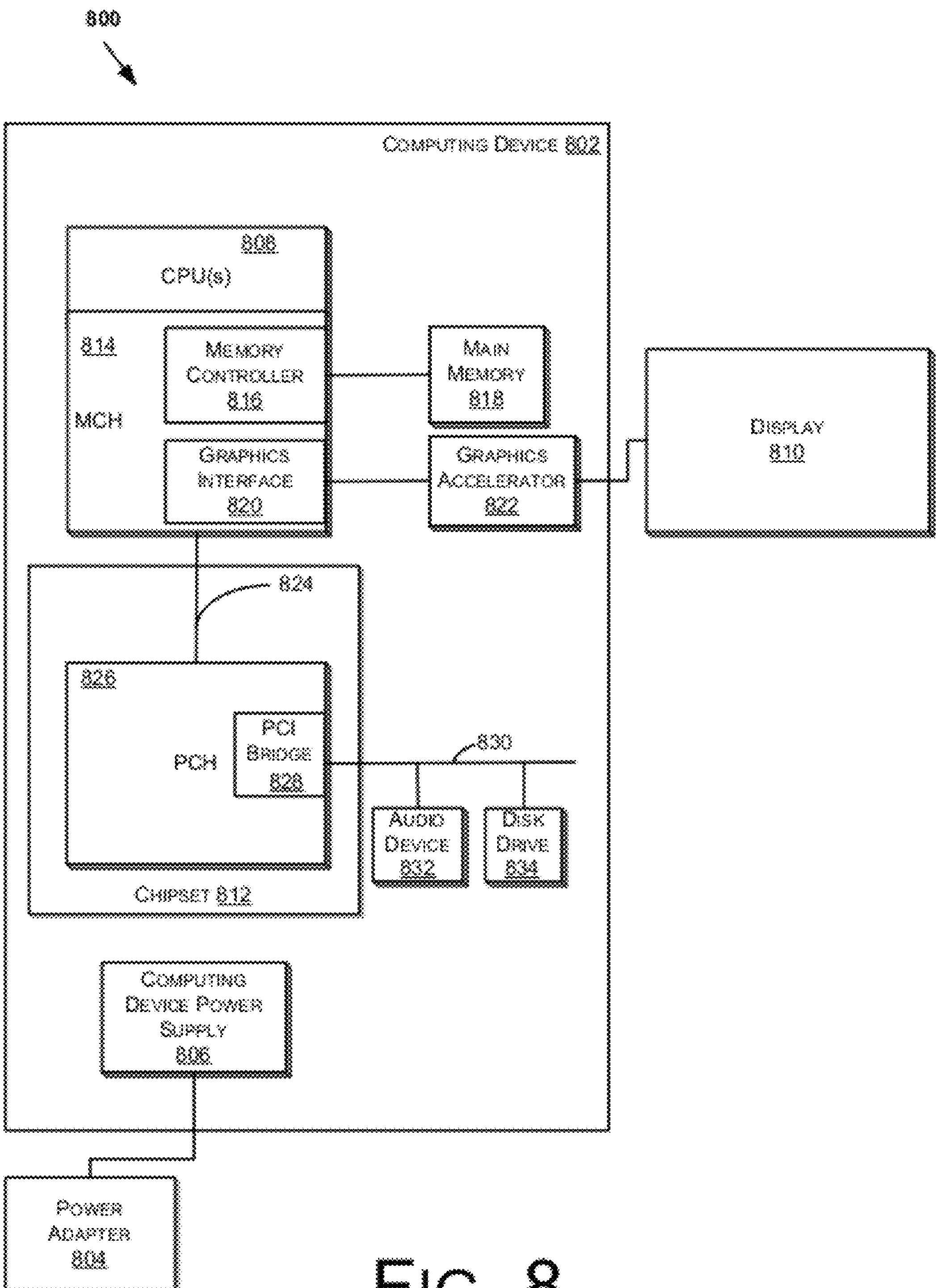

800
Computing Device 802
808
CPU(s)
814
MCH
Memory Controller 816
Graphics Interface 820
Main Memory 818
Graphics Accelerator 822
Display 810
824
826
PCH
PCI Bridge 828
830
Audio Device 832
Disk Drive 834
Chipset 812
Computing Device Power Supply 806
Power Adapter 804

FIG. 8

INTEGRATED ANTENNA ASSEMBLY

RELATED APPLICATIONS

None.

BACKGROUND

The subject matter described herein relates generally to the field of electronic communication and more particularly to antenna assemblies which may be used in electronic devices.

Many electronic devices such as notebook and laptop computers, personal digital assistants (PDAs), and the like include one or more wireless transceivers to send and receive data via wireless networks. Multi-mode devices, which can transceiver data on multiple different wireless networks, may share hardware, e.g., transmitters, receivers, antennas, etc., in order to reduce both the cost and size of a device. Accordingly, integrated antenna assemblies, and particularly antenna assemblies which may be used on multiple networks, may find utility.

BRIEF DESCRIPTION OF THE DRAWINGS

The detailed description is described with reference to the accompanying figures.

FIGS. **1**A-**1**C are schematic illustrations of a circuit board assembly comprising an integrated antenna assembly according to some embodiments.

FIG. **2** is a schematic illustration of the electric field distribution of an integrated antenna assembly, according to some embodiments.

FIG. **3** is a graph illustrating the return loss of an integrated antenna assembly, according to some embodiments.

FIG. **4** is a graph illustrating efficiency and peak gain performance for an integrated antenna assembly, according to some embodiments.

FIGS. **5**A and **5**B are schematic illustrations of top and side views, respectively, of radiation patterns for an integrated antenna assembly, according to some embodiments.

FIG. **6** is a schematic illustration of an RF communication capability which may be integrated into an electronic device, according to embodiments.

FIG. **7** is a schematic illustration of an electronic device which includes a wireless communication capability, according to some embodiments.

FIG. **8** is a schematic illustration of a computing system which may be adapted to include an integrated antenna assembly, according to some embodiments.

DETAILED DESCRIPTION

In the following description, numerous specific details are set forth to provide a thorough understanding of various embodiments. However, it will be understood by those skilled in the art that the various embodiments may be practiced without the specific details. In other instances, well-known methods, procedures, components, and circuits have not been illustrated or described in detail so as not to obscure the particular embodiments.

FIGS. **1**A-**1**C are schematic illustrations of a circuit board assembly comprising an integrated antenna assembly according to some embodiments. Referring to FIGS. **1**A-**1**C, in some embodiments the circuit board assembly comprises a motherboard **140**. The particular configuration of the motherboard **140** is not critical. In some embodiments the motherboard **140** may be configured as a motherboard for an

electronic device, e.g., a computer system, a mobile communication device, or the like. Motherboard **140** may comprise various circuitry and expansion slots to accommodate plug-in devices such as, e.g., integrated circuits, memory devices, and the like.

An antenna assembly **100** is mounted on motherboard **140**. In some embodiments the antenna assembly **110** may comprise a computer expansion card. By way of example, in some embodiments the computer expansion card **110** may comprise a peripheral component interconnect express (PCI-E) half-mini card (HMC), although other cards may be used.

In some embodiments the computer expansion card **110** may be mounted adjacent the motherboard **140** by a suitable fastener via one or more mounting holes **114**, **116** disposed at respective corners of the computer expansion card **110**. Further, computer expansion card **110** comprises a plurality of grounding pins **120** to provide a connection to ground plane **142** via the motherboard **140**.

In embodiments in which the computer expansion card **110** is embodied as a PCI-E half-mini card the computer expansion card measures approximately 31.90 millimeters (mm) in length by 30.0 mm in width and 1.00 mm in thickness. In alternate embodiments the computer expansion card **110** may measure between 30.00 and 60.00 mm in length and 25.0 and 35.0 mm in width, and up to 5.0 mm in thickness. The computer expansion card **110** may comprise an array of contacts or pins disposed along an edge to establish electrical contact with corresponding pins or contacts in a socket coupled to the motherboard **140**.

Referring now to FIGS. **1**B and **1**C, in some embodiments the computer expansion card **110** may be embodied as a multi-layer card which comprises at least one layer defining a radiating element **112**. Radiating element **112** may be implemented as a substantially planar layer of electrically conductive metal. In the embodiment depicted in FIGS. **1**A-**1**C the radiating element **112** extends across substantially the entire area of the computer expansion card **110**. In alternate embodiments the radiating element **112** may extend across only a portion of the area of computer expansion card **112**. In alternate embodiments, the radiating element may comprise a metallic shielding attached to the computer expansion card **110**, either on the top or bottom of the computer expansion card **110**. The radiating element **112** may comprise a first part which is a printed layer and a second part which is extended to the shield through metallic contact.

At least a portion of the motherboard **140** comprises a layer which defines a ground plane **142** for the antenna assembly **100**. In the embodiment depicted in FIGS. **1**B-**1**C the ground plane **142** extends throughout the entire area of the motherboard **142**. However, it will be appreciated that the ground plane **142** need not cover the entire area of the motherboard **140**.

One skilled in the art will recognize that the radiating element **112** of the computer expansion card **110** and the ground plane **142** of the motherboard **140** along with ground pins **120** model a planar inverted F antenna (PIFA) structure. The ground pins **120** provide grounding for the antenna structure and the ground plane **142** in the motherboard **140** functions as the antenna ground plane. As illustrated in FIG. **1**C, in use an RF signal may be fed into the antenna via one of the mounting holes **114**, **116** to the ground plane on the mother board, while leaving the other not electrically connected to the mother board ground. In the embodiment depicted in FIG. **1**C the RF signal is fed via mounting hole **116**, but one skilled in the art will recognize that either mounting hold could be used. The RF signal could be driven directly from radio on the HMC or other sources. The signal is connected to pad(s) near the mounting hole either on top or bottom of the HMC. A metallic screw can be used to mount the card to the mother board, also providing metallic contact between the signal pad near the hole and the ground plane of the mother board. Other ways of connecting the signal pad to the ground plane of mother board can also be used, such as making contact between the metallic stud on the mother board to the signal pad on bottom or both top and bottom.

The resonance frequency of the antenna assembly **100** is a function of the size of the radiating element **112** and the impedance matching of the antenna assembly **100** at the resonance frequency is a function of the location of the feed point and the grounding pins. In embodiments in which the radiating element **112** extends across substantially the entire area of the computer expansion card **110** the antenna assembly exhibits a natural resonance frequency centered approximately at 2.5 GHz. This is illustrated in FIG. **2**, which is a schematic illustration of the electric field distribution of an integrated antenna assembly **100**, according to some embodiments.

FIG. **3** is a graph illustrating the return loss of an integrated antenna assembly **100**, according to some embodiments. Referring to FIG. **3**, the antenna assembly **100** exhibits a return loss better than −15 dB across the 2.4 GHz ISM band, and a return loss better than −10 dB across the frequency spectrum from 2.35 GHz to 2.6 GHz. FIG. **4** is a graph illustrating efficiency and peak gain performance for an integrated antenna assembly, according to some embodiments. As illustrated in FIG. **4**, the antenna assembly provides strong, consistent gain and efficiency across the frequency spectrum from 2.35 GHz to 2.6 GHz.

FIGS. **5**A and **5**B are schematic illustrations of top and side views, respectively, of radiation patterns for an integrated antenna assembly **100**, according to some embodiments. As illustrated in FIGS. **5**A and **5**B, the antenna assembly **100** exhibits a near-uniform, omni-directional radiation pattern.

One skilled in the art will recognize that an antenna assembly **100** with the performance characteristics illustrated in FIGS. **2**-**5** is suitable for use in multimode devices, e.g., as an antenna structure for both WiFi networks operating in the 2.4 GHz frequency spectrum and Bluetooth networks operating in the 2.4 GHz frequency spectrum region.

In some embodiments the antenna assembly **100** may be incorporated into the RF communication capability **600** of an electronic device. Referring now to FIG. **6**, a block diagram of an RF communication capability **600** in accordance with one or more embodiments will be discussed. FIG. **6** depicts the major elements of an RF communication capability **600**, however fewer or additional elements may be included in alternative embodiments in addition to various other elements that are not shown herein, and the scope of the claimed subject matter is not limited in these respects.

RF communication capability **600** may comprise a baseband processor **610** coupled to memory **612** for performing the control functions of RF communication capability. Input/output (I/O) block **614** may comprise various circuits for coupling RF communication capability to one or more other devices or components of an electronic device. For example, I/O block **614** may include one or more Ethernet ports and/or one or more universal serial bus (USB) ports for coupling RF communication capability **600** to a modem or other devices. For wireless communication, RF communication capability **600** may further include a radio-frequency (RF) modulator/demodulator **620** for modulating signals to be transmitted and/or for demodulating signals received via a wireless communication link.

A digital-to-analog (D/A) converter **616** may convert digital signals from baseband processor **610** to analog signals for modulation and broadcasting by RF modulator/demodulator **620** via analog and/or digital RF transmission techniques. Likewise, analog-to-digital (A/D) converter **618** may convert analog signals received and demodulated by RF modulator/demodulator **620** digital signals in a format capable of being handled by baseband processor **610**. Power amplifier (PA) **622** transmits outgoing signals via one or more antennas **628** and/or **630**, and low noise amplifier (LNA) **624** receives one or more incoming signals via antenna assembly **100**, which may be coupled via switching and matching module **630** to control such bidirectional communication. In one or more embodiments, RF communication capability **600** may implement single input, single output (SISO) type communication, and in one or more alternative embodiments RF communication capability may implement multiple input, multiple output (MIMO) communications, although the scope of the claimed subject matter is not limited in these respects.

FIG. **7** is a schematic illustration of an electronic device **716** which includes a wireless communication capability, according to some embodiments. Referring to FIG. **7**, in some embodiments electronic device **716** may be embodied as a mobile telephone, a personal digital assistant (PDA), a laptop computer, or the like. Electronic device **716** may include an RF transceiver **750** to transceive RF signals and a signal processing module **752** to process signals received by RF transceiver **750**.

RF transceiver **750** may implement a local wireless connection via a protocol such as, e.g., Bluetooth or 802.11x. IEEE 802.11a, b or g-compliant interface (see, e.g., IEEE Standard for IT-Telecommunications and information exchange between systems LAN/MAN—Part II: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications Amendment 4: Further Higher Data Rate Extension in the 2.4 GHz Band, 802.11G-2003). Another example of a wireless interface would be a general packet radio service (GPRS) interface (see, e.g., Guidelines on GPRS Handset Requirements, Global System for Mobile Communications/GSM Association, Ver. 3.0.1, December 2002).

Electronic device **716** may further include one or more processors **754** and a memory module **756**. As used herein, the term "processor" means any type of computational element, such as but not limited to, a microprocessor, a microcontroller, a complex instruction set computing (CISC) microprocessor, a reduced instruction set (RISC) microprocessor, a very long instruction word (VLIW) microprocessor, or any other type of processor or processing circuit. In some embodiments, processor **754** may be one or more processors in the family of Intel® PXA27x processors available from Intel® Corporation of Santa Clara, Calif. Alternatively, other CPUs may be used, such as Intel's Itanium®, XEON™, ATOM™, and Celeron® processors. Also, one or more processors from other manufactures may be utilized. Moreover, the processors may have a single or multi core design. In some embodiments, memory module **756** includes random access memory (RAM); however, memory module **756** may be implemented using other memory types such as dynamic RAM (DRAM), synchronous DRAM (SDRAM), and the like.

Electronic device **716** may further include one or more input/output interfaces such as, e.g., a keypad **758** and one or more displays **760**. In some embodiments electronic device **716** comprises one or more camera modules **762** and an image signal processor **764**.

FIG. **8** is a schematic illustration of a computer system **800** which may include a wireless communication capability in accordance with some embodiments. The computer system **800** includes a computing device **802** and a power adapter **804** (e.g., to supply electrical power to the computing device **802**). The computing device **802** may be any suitable computing device such as a laptop (or notebook) computer, a personal digital assistant, a desktop computing device (e.g., a workstation or a desktop computer), a rack-mounted computing device, and the like.

Electrical power may be provided to various components of the computing device **802** (e.g., through a computing device power supply **806**) from one or more of the following sources: one or more battery packs, an alternating current (AC) outlet (e.g., through a transformer and/or adaptor such as a power adapter **804**), automotive power supplies, airplane power supplies, and the like. In some embodiments, the power adapter **804** may transform the power supply source output (e.g., the AC outlet voltage of about 110 VAC to 240 VAC) to a direct current (DC) voltage ranging between about 7 VDC to 12.6 VDC. Accordingly, the power adapter **804** may be an AC/DC adapter.

The computing device **802** may also include one or more central processing unit(s) (CPUs) **808**. In some embodiments, the CPU **808** may be one or more processors in the Pentium® family of processors including the Pentium® II processor family, Pentium® III processors, Pentium® IV, or CORE2 Duo processors available from Intel® Corporation of Santa Clara, Calif. Alternatively, other CPUs may be used, such as Intel's Itanium®, XEON™, and Celeron® processors. Also, one or more processors from other manufactures may be utilized. Moreover, the processors may have a single or multi core design.

A chipset **812** may be coupled to, or integrated with, CPU **808**. The chipset **812** may include a memory control hub (MCH) **814**. The MCH **814** may include a memory controller **816** that is coupled to a main system memory **818**. The main system memory **818** stores data and sequences of instructions that are executed by the CPU **808**, or any other device included in the system **800**. In some embodiments, the main system memory **818** includes random access memory (RAM); however, the main system memory **818** may be implemented using other memory types such as dynamic RAM (DRAM), synchronous DRAM (SDRAM), and the like. Additional devices may also be coupled to the bus **810**, such as multiple CPUs and/or multiple system memories.

The MCH **814** may also include a graphics interface **820** coupled to a graphics accelerator **822**. In some embodiments, the graphics interface **820** is coupled to the graphics accelerator **822** via an accelerated graphics port (AGP). In some embodiments, a display (such as a flat panel display) **840** may be coupled to the graphics interface **820** through, for example, a signal converter that translates a digital representation of an image stored in a storage device such as video memory or system memory into display signals that are interpreted and displayed by the display. The display **840** signals produced by the display device may pass through various control devices before being interpreted by and subsequently displayed on the display.

A hub interface **824** couples the MCH **814** to a platform control hub (PCH) **826**. The PCH **826** provides an interface to input/output (I/O) devices coupled to the computer system **800**. The PCH **826** may be coupled to a peripheral component interconnect (PCI) bus. Hence, the PCH **826** includes a PCI bridge **828** that provides an interface to a PCI bus **830**. The PCI bridge **828** provides a data path between the CPU **808** and peripheral devices. Additionally, other types of I/O interconnect topologies may be utilized such as the PCI Express™ architecture, available through Intel® Corporation of Santa Clara, Calif.

The PCI bus **830** may be coupled to an audio device **832** and one or more disk drive(s) **834**. Other devices may be coupled to the PCI bus **830**. In addition, the CPU **808** and the MCH **814** may be combined to form a single chip. Furthermore, the graphics accelerator **822** may be included within the MCH **814** in other embodiments.

Additionally, other peripherals coupled to the PCH **826** may include, in various embodiments, integrated drive electronics (IDE) or small computer system interface (SCSI) hard drive(s), universal serial bus (USB) port(s), a keyboard, a mouse, parallel port(s), serial port(s), floppy disk drive(s), digital output support (e.g., digital video interface (DVI)), and the like. Hence, the computing device **802** may include volatile and/or nonvolatile memory.

Thus, described herein is an integrated antenna assembly which may achieve high efficiency and low return loss across a frequency spectrum from 2.35 GHz to 2.6 GHz. In some embodiments the antenna assembly **100** may be formed as a component of a computer expansion card such as a PCI-E card connectable to a motherboard of an electronic device. Thus, the antenna assembly may be integrated into electronic devices, e.g., mobile computing devices or the like.

In the description and claims, the terms coupled and connected, along with their derivatives, may be used. In particular embodiments, connected may be used to indicate that two or more elements are in direct physical or electrical contact with each other. Coupled may mean that two or more elements are in direct physical or electrical contact. However, coupled may also mean that two or more elements may not be in direct contact with each other, but yet may still cooperate or interact with each other.

Reference in the specification to "one embodiment" or "some embodiments" means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least an implementation. The appearances of the phrase "in one embodiment" in various places in the specification may or may not be all referring to the same embodiment.

Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that claimed subject matter may not be limited to the specific features or acts described. Rather, the specific features and acts are disclosed as sample forms of implementing the claimed subject matter.

What is claimed is:

1. An antenna assembly, comprising:

a computer expansion card mounted adjacent a printed circuit board and comprising a metallic layer which forms a radiating element comprising a first part which is a printed layer and a second part which extends to a metallic shield, wherein the computer expansion card comprises:

a first mounting hole disposed at a first corner of the computer expansion card and a second mounting hole disposed at a second corner of the computer expansion card, opposite the first corner, to receive a fastener to mount the computer expansion card on the printed circuit board wherein the fastener is positioned through one of the first mounting hole or the second mounting hole and provides the feed line for the antenna assembly; and

a plurality of grounding pins, at least one of which provides a connection between the radiating element on the computer expansion card and a ground plane on the printed circuit board, such that the ground plane on the printed circuit board provides a ground plane for the radiating element; and

a feed line coupled to the radiating element.

2. The antenna assembly of claim **1**, wherein:

the computer expansion card measures between 35.00 and 60.00 millimeters in length and between 25.00 and 35.00 millimeters in width; and

the radiating element extends across the entire width and length of the expansion card.

3. The antenna assembly of claim **1**, wherein:

the computer expansion card comprises a Peripheral Component Interconnect Express (PCI-E) card.

4. The antenna assembly of claim **1**, wherein the antenna assembly has a resonance frequency range centered approximately at 2.5-GHz.

5. The antenna assembly of claim **1**, wherein assembly is coupled to at least one of a WiFi radio or a Bluetooth radio.

6. A printed circuit board assembly, comprising:

a motherboard,

a computer expansion card mounted adjacent a printed circuit board and comprising a metallic layer which forms a radiating element comprising a first part which is a printed layer and a second part which extends to a metallic shield, wherein the computer expansion card comprises:

first mounting hole disposed at a first corner of the computer expansion card and a second mounting hole disposed at a second corner of the computer expansion card, opposite the first corner, to receive a fastener to mount the computer expansion card on the printed circuit board wherein the fastener is positioned through one of the first mounting hole or the second mounting hole and provides the feed line for the antenna assembly; and

a plurality of grounding pins, at least one of which provides a connection between the radiating element on the computer expansion card and a ground plane on the printed circuit board,

wherein at least a portion of the motherboard defines a ground plane for the radiating element.

7. The printed circuit board assembly of claim **6**, wherein:

the computer expansion card measures between 30.00 and 60.00 millimeters in length and between 25.00 and 35.00 millimeters in width; and

the radiating element extends across the entire width and length of the expansion card.

8. The printed circuit board assembly of claim **6**, wherein:

the computer expansion card comprises a Peripheral Component Interconnect Express (PCI-E) card.

9. The printed circuit board assembly of claim **8**, wherein an RF signal is fed into the antenna via at least one of the first mounting hole or the second mounting hole.

10. The printed circuit board assembly of claim **9**, wherein the radiating element has a resonance frequency range centered approximately at 2.5 GHz.

11. The printed circuit board assembly of claim **6**, wherein computer expansion card is coupled to at least one of a WiFi radio or a Bluetooth radio.

12. An electronic device, comprising:

at least one radio; and

an antenna assembly coupled to the at least one radio, the antenna assembly comprising:

a computer expansion card mounted adjacent a printed circuit board and comprising a metallic layer which forms a radiating element comprising a first part which is a printed layer and a second part which extends to a metallic shield, wherein the computer expansion card comprises:

first mounting hole disposed at a first corner of the computer expansion card and a second mounting hole disposed at a second corner of the computer expansion card, opposite the first corner, to receive a fastener to mount the computer expansion card on the printed circuit board wherein the fastener is positioned through one of the first mounting hole or the second mounting hole and provides the feed line for the antenna assembly; and

a plurality of grounding pins, at least one of which provides a connection between the radiating element on the computer expansion card and a ground plane on the printed circuit board, such that the ground plane on the printed circuit board provides a ground plane for the radiating element,

wherein an RF signal is fed into the antenna assembly via one of the mounting holes.

13. The electronic device of claim **12**, wherein:

the computer expansion card measures between 30.00 and 60.00 millimeters in length and between 25.00 and 35.00 millimeters in width; and

the radiating element extends across the entire width and length of the expansion card.

14. The electronic device of claim **12**, wherein:

the computer expansion card comprises a Peripheral Component Interconnect Express (PCI-E) card.

15. The electronic device of claim **12**, wherein the antenna assembly has a resonance frequency range centered approximately at 2.5 GHz.

16. The electronic device of claim **12**, wherein the antenna assembly is coupled to at least one of a WiFi radio or a Bluetooth radio.

* * * * *